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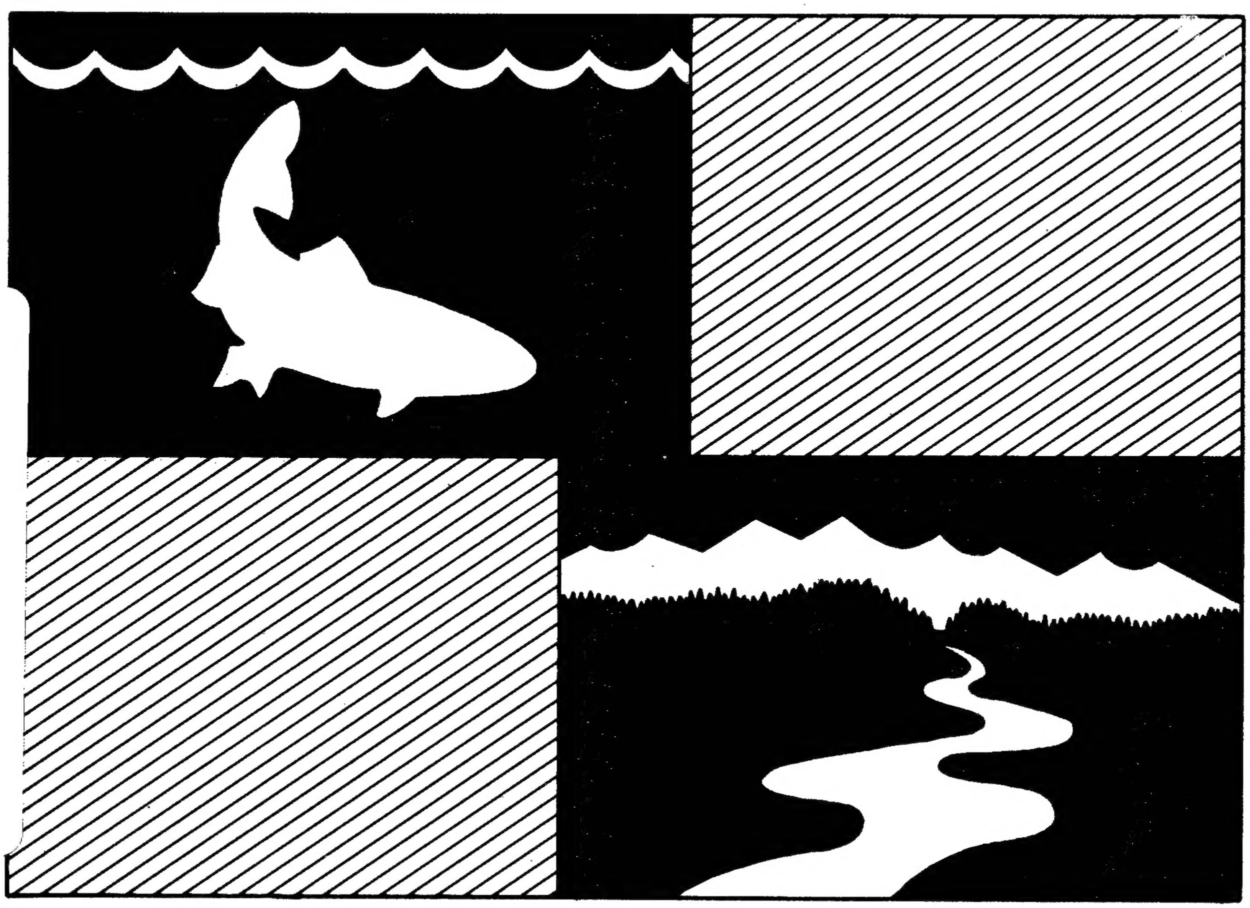
ANNOTATED BIBLIOGRAPHY OF ECONOMIC LITERATURE ON INSTREAM FLOWS



Fish and Wildlife Service

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ANNOTATED BIBLIOGRAPHY OF ECONOMIC LITERATURE ON INSTREAM FLOWS

by

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PREFACE

This bibliography focuses almost exclusively on economic research that deals with instream flows. Some of the articles cited or discussed are slanted toward policy and management issues and analysis. It should come as no surprise that there is an extensive recent literature on instream flows. What is surprising is that there is a relatively extensive recent literature on the economics of instream flow issues. Much of the recent public concern with rivers and streams has centered around water quality and industrial pollution; this is reflected in much of the key Federal environmental legislation since 1960 (e.g., NEPA and the Clean Water Act). The recent economic research on instream flows, however, deals with the problem of imputing social and economic values to those recreation, aesthetic, and ecological benefits that stem from maintaining rivers and streams in a free-flowing state. Thus the economics literature deals directly with the thorny issue of the valuation of nonmarket activities and resources.

It is clear that this topic will continue to draw interest from economists. Prospective topics for research in the near future include: efficient pricing of permits and setting of entrance fees; income and multiplier effects associated with the use of riverine recreation resources; and the intertemporal modeling problems associated with imputing benefits and values to nonmarket benefits provided by public goods and assets of widely varying durability.

In this bibliography I discuss certain articles more thoroughly than the others. The order of listing is by publication date, and the papers span a period of 18 years. The choice of papers that were included for discussion was somewhat arbitrary, but repeated consultations with experts enhanced the objectivity of the selection criteria. I unfailingly followed their advice when they asked me to include specific articles. I usually ignored their advice when they requested greater selectivity or more sharply opinionated evaluations of the literature.

The following bibliographic data bases were retrospectively searched for scholarly articles dealing with the problems of inputing economic values to instream flows: Aquatic Sciences and Fisheries Abstracts, Dissertation Abstracts Online, Economic Literature Index, National Technical Information Service, and Water Resources Abstracts.

Comments or questions regarding this bibliography should be sent to the author at the address on the title page.

CONTENTS

ACKNOWLEDGMENTS

I would like to thank Dr. D.A. King, Dr. J.B. Loomis, Dr. R.G. Walsh, and Dr. T.C. Brown for helpful discussions on this topic.

INTRODUCTION

This bibliography is intended for the use of economists and policy analysts who have little aquaintance with natural resource economics, and natural resource professionals who have some background in economic analysis and wish to sharpen their appreciation of the specialized methods being used to value the nonmarket uses of riverine resources. It is not intended to serve as a first primer on natural resource economics. This brief introductory section is included to familiarize the reader with the rather specialized language and analytic techniques used in this field. Moreover, summary discussions of these techniques are not available in introductory or intermediate-level economics textbooks.

A key difficulty in economic analysis lies in the need that economists have to express common-sense terms such as "demand" or "supply" in a precise way; this facilitates the interpretation of data and is a powerful aid in making internally consistent policy analysis. Natural resource economists would like to find a consistent, intuitively plausible measure of the social welfare benefits conferred by some good or service. The most common fallacy noneconomists make in this field is to use expenditures as a measure of well-being or benefits. This measure is defective; expenditures may rise, while benefits fall. The following simple example should clarify the issue. Suppose that a certain population center, in the 1940's, is located 5 miles from a riverine recreation site. Suppose that a factory opens up 15 miles away from the site during the 1950's, and closes at the end of the 1960's; and that during this 20-year period, the bulk of this region's populace resides 15 miles from the site, close to the factory. In the 1970's, the populace of the region returns to the old population center, 5 miles from the recreation site. The benefits conferred by the site diminished during the 1950's and 1960's, even though travel (and even total) expenditures associated with the use of the site may have risen during this period.

Intuition and economic analysis suggest that accurate estimates of benefits conferred by a good or service provide quantitative indices of the availability of good substitutes for the good or service in question. The fewer low-priced substitutes, the greater the benefits conferred by the good. The prices (quantities) of available substitutes may be needed to correctly specify empirically estimated demand (supply) curves. If so, omission of these variables will produce biased estimates of net benefits conferred if the approach used to estimate benefits conferred is based on the shape and position of an emprically estimated demand (supply) curve. In general, a good grasp of the meaning of both demand and supply (curves) is needed to produce sound estimates of benefits conferred by some commodity. Demand and supply curves are discussed in the following section that deals with various techniques for estimating benefits conferred by outdoor recreation sites.

CONSUMER AND PRODUCER SURPLUS AS MEASURES OF NET ECONOMIC BENEFITS AND THE TRAVEL COST METHOD

The commonly used measure of social benefits conferred by a good or service is the area of the triangular region between the horizontal line that extends between the price axis and the intersection of the supply and demand curve (Figure 1). This region, DPP', is marked by horizontal lines; market expenditures are given by the rectangle OPP'A. This area is called the consumer's surplus conferred by the good or service. The triangular region between this same horizontal line and the supply curve is called the producer's surplus. This region, SPP', is marked by vertical lines; the horizontal axis measures quantity per unit time, and the vertical axis measures price. Often these two areas are added together to form a total social surplus estimate; but for recreation sites, which are often owned and managed by government agencies, consumer surplus is usually used as the relevant index of social benefits. Since the entrance fee for the site is usually zero or a low nominal value, the ratio of market expenditures to consumer surplus is relatively low; little of the potential consumer surplus is extracted as revenue, and nonmarket benefits conferred by the site can be substantial. Clearly this raises difficulties for recreation economists, since actual market data cannot be used to estimate demand curves for recreation sites. Participation rates for site usage will diminish as recreationists move further away from the site. Hence there is a systematic (inverse) relation between travel costs and per capita trips that has the same general shape as a demand curve. This inverse relation forms the basis of the travel cost method (TCM).

Historically, the estimation of TCM demand curves involves drawing concentric circles around the site, and determining the participation rate and travel cost associated with each of these circular regions. For the circular region closest to the site, the participation rate is highest and travel costs are lowest. For the circular region farthest away from the site, the participation rate is lowest and the travel cost highest. The triangular area under the demand curve, but above a zone's mean travel cost, is taken as the consumer surplus associated with travel cost method estimates of recreation site demand curves. Summation of the consumer surplus over travel zones gives the aggregate consumer surplus estimate (Clawson and Knetsch 1966; Samples and Bishop 1986).

The travel cost method is based on the estimation of the area beneath an empirical demand curve. In principle and practice, the price of travel or the number of trips to competing outdoor recreation sites may be needed as independent variables for accurate regression estimates of the travel cost demand curve (the number of trips per thousand residents per annum versus the travel cost). These variables may also be needed to produce unbiased estimates of the net social benefits conferred by the site.

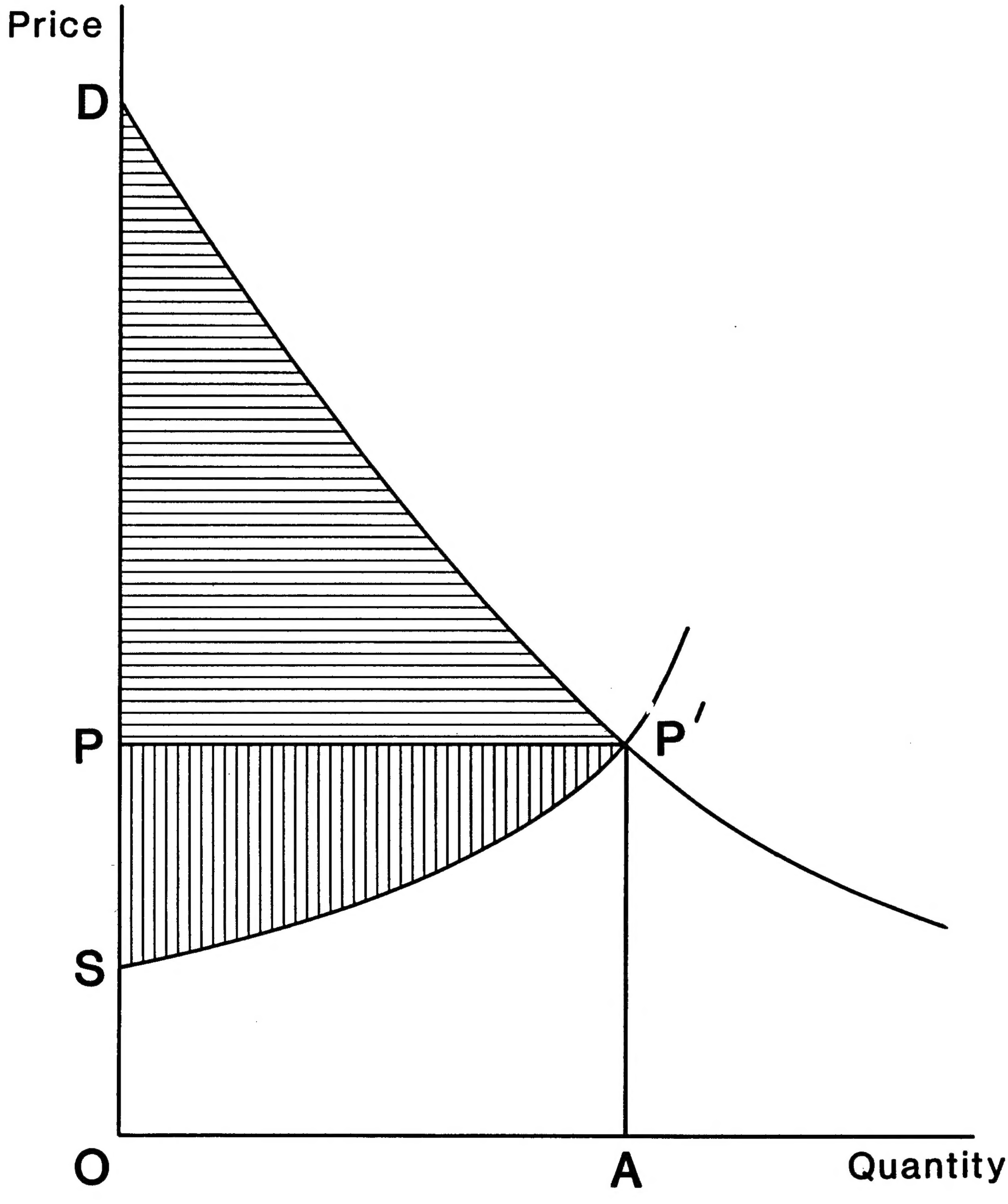

Figure 1. Social benefits estimation using market supply and demand curves.

In practice, TCM estimates of benefits conferred are produced by regression estimates of participation rates on a number of independent variables. The key independent variable is the cost of travel to the site. If the travel cost variable is underestimated by the omission of the cost of foregone wages as a component of total travel costs, the estimates of benefits based on the estimated demand equation will markedly underestimate the true benefits conferred by the site. Other useful independent variables for the estimation of travel cost demand curves include the real income of the households, and socio-economic variables such as the sex of the head of the household and the level of education of the household. To calculate the benefits conferred by the site, all the other independent variables (except for the travel cost variable) are held at their mean value.

The estimated travel cost demand curve can be used for other practical purposes, particularly forecasts of future levels of demand that involve shifts in both demographic and economic variables.

CONCEPTUAL PROBLEMS WITH CONSUMER SURPLUS MEASURES

There are important shortcomings in the traditional consumer surplus concept. Discussion of certain aspects of these defects is beyond the scope of this paper, but it may be useful to note that the Marshallian (Marshall 1920) measures of consumer surplus (the area under the demand curve but above the horizontal price line) are nontransitive with respect to multiple price changes in interrelated markets. When prices in two interrelated markets change, the change in the Marshallian consumer surplus is the sum of the changes in the relevant regions underneath the demand curves of the two goods (Just et al. 1982).

For definiteness, suppose that an exogenous shift in the supply curve of outboard motors leads to a change in the price of outboard motors, in turn causing a shift in the demand (schedule) curve for small boats, and that this latter shift induces a change in the price of small boats. The total change in consumer surplus depends on the sequential order of the analysis; if the consumer surplus change in the market for outboard motors (after the price changes) is estimated first, and then the change in consumer surplus in the boat market is added to this initial value, one value of the total change in consumer surplus emerges from the analysis. But if the sequence of the analysis is changed, and the analysis starts with the motor market first, another value for the consumer surplus results (Just et al. 1982).

It is easy to see that an economic welfare measure that is free of this defect is highly desirable. Hicks (1943) provided two such measures (actually four; however, only two of the measures of consumer surplus that Hicks suggested are widely used today). These two measures distinguish sharply between the level of consumer welfare before and after an economic change.

One of these measures is called the compensating variation. This is the amount of money income that must be taken away from a consumer, after a change

in some economic variable, in order to make him exactly as well off as he was before the change took place. The equivalent variation is the amount of money income that must be taken from a consumer in order to make him exactly as well off as he is after the change takes place (under the hypothetical presumption that the change has not occurred). If the change is a fall in price, the compensating variation must be positive (the consumer must lose income if he is to be as well off as he was before the decline in price).

The equivalent variation must be negative (Just et al. 1982) in the case of a fall in price (the two measures will always have opposite algebraic signs). These two estimates of consumer surplus are now known by the generic term of willingness-to-pay approaches to consumer benefits estimates. Natural resource economists have recently developed willingness-to-pay techniques for estimating the benefits conferred by outdoor recreation sites and other natural resource amenity values.

The Hicksian measures are free of the internal defect (nontransitivity) of traditional Marshallian consumer surplus. But while it is flawed as a theoretical measure of net benefits conferred, Marshallian consumer surplus is based on market behavior and consumer responses to recorded prices. Since economists have reason to believe that the Marshallian consumer surplus measure provides a very good approximation (Just et al. 1982) to the Hicksian consumer surplus values, the distinction is a moot one for many practical purposes.

If the quality of a good or service that is bought in the market place changes, the price of the good will also change. Thus the shift in the Marshallian consumer surplus induced by the quality change will capture most of the change in aggregate benefits conferred generated by quality shifts for market goods (Houthaker 1952). Shifts in the demand for nonmarket goods and services that stem from quality changes might underestimate the increase in net aggregate benefits conferred. Under certain circumstances, however, the shift in trips will completely quantify the increase in benefits conferred from qualitative improvements in outdoor recreation sites. Thus the travel cost method can, in certain cases, completely capture the increase in benefits from improvements in instream flows (Loomis 1987); abundant data may be needed for reliable estimates of the aggregate marginal social benefits of instream flow.

THE CONTINGENT VALUATION METHOD

Natural resource economists use carefully tailored questionnaires called survey instruments to make contingent value method (CVM) estimates of the willingness-to-pay for natural resource amenities. These questionnaires solicit information from respondents by engaging them in a hypothetical bidding game. The recreationist is queried as to the maximum amount he or she would pay rather than give up the use of the site or amenity (this is often simply called the willingness-to-pay of the respondent if there is no possibility of confusion with the theoretical Hicksian measures of consumer surplus). Or he

may be queried as to the minimal amount of money he or she would be willing to take in exchange for the use of the site (willingness-to-sell).

The CVM is an important tool for estimating the benefits conferred by instream flows because a great deal of data is required to estimate the shift in a travel cost demand curve with varying levels of instream flows. Moreover, the shift in the travel cost demand curve may measure only a part of the increase in benefits conferred from improvements in flow levels.

The sums of money that a recreationist would exchange for a natural resource amenity are known as bids; the bids usually vary by fixed incremental sums. If there is a fixed maximum bid, the instrument is said to be a closed-end bidding game; if there is no predetermined maximum bid, the instrument is said to be an open-ended bidding game. There are various techniques for summing over the individual bids to estimate the aggregate net benefits conferred.

Both closed-end and open-ended bidding games are fixed-sum bidding games. The aggregate bid is (roughly) calculated as the sum of the individual bids. Regression analysis is often used to refine the technique so that the total bid is the product of the "true" average bid (given the socio-economic characteristics of the populace that is making the aggregate bid) times the size of the population.

Dichotomous bidding games elicit information as to the aggregate bid in the form of a set of probabilities. Thus a respondent is asked to reply with a yes or no as to whether he would be willing to add a certain fixed sum amount to his initial bid. For each fixed incremental sum, there is a probability of eliciting a yes that can be calculated from the responses of the respondents. These probabilities can be used to directly calculate the aggregate bid for given incremental sums. Correction for the socio-economic characteristics of the population is possible through the use of a qualitative response regression analysis called a probit regression, in which the response probabilities are the dependent variables and the socio-economic characteristics of the population are the independent variables.

Contingent value methods can be tailored to conform to the Hicksian measures of consumer surplus. However, bidding game techniques can only simulate market responses (McKean and Walsh 1986) whereas the Hicksian measures give the true changes in benefits conferred by real changes in prices, quantities, and qualities. When regression analysis is used to aid in calculating the aggregate bid, the size of the bid is regressed (is the independent variable) on such socio-economic characteristics as race, income, education level, total outdoor recreation days, and travel costs. The mean bid of the populace is then calculated using the estimated regression coefficients. The mean bid times the population size may be used as the estimate of net benefits conferred. However, some researchers use the median bid of the populace (times the population) as the estimate of net benefits conferred. Nonrespondents may be considered as entering a bid of zero dollars, or they may be excluded from the sample.

The principal criticism of the contingent value method is simply that it is not based on actual market behavior. Many economists believe that the benefits estimated with the contingent valuation survey instruments are flawed by several types of bias. These include (Thayer 1981) starting point bias (the size of the initial amount that the recreationists is asked to exchange for his use of the resource may influence the size of his maximum bid); hypothetical bias (the inability or unwillingness of the respondents to predict what they actually would pay if required to do so), and strategic bias (the maximum bids may differ from the true willingness-to-pay of the respondents because the participant may attempt to use the questionnaire to direct the expenditure of public funds). Also, if instream flows confer off-site benefits, the TCM will underestimate the marginal social value of a unit of instream flow (Loomis 1987), but the CVM can capture both on-site and off-site benefits.

The use of this approach to impute off-site values to an outdoor recreation site, however, is controversial. For example, the survey instrument may ask respondents to estimate the existence value of the site. This is the dollar value that is attached by respondents to the fact that the site exists. Nevertheless, the potential of willingness-to-pay approaches to estimate changes in benefits conferred from on-site quality changes strongly suggest that this method will be widely used to value changes in quality variables such as instream flow levels.

THE HEDONIC PROPERTY METHOD

The hedonic property method for estimating environmental benefits also utilizes market data, so it is akin to the travel cost method. The commodity demanded is not a recreation trip; it is recreation experience or the presence of an environmental attribute that must be carefully defined. The price of this experience includes as components all of the prices of the goods that are purchased that enhance the quality of this experience, including the travel cost, equipment prices, entrance fees, and foregone income.

COMMON ECONOMIC TERMS

Four important terms that are often used in natural resource allocation discussions are the following:

Demand curve. Obviously, it would take a textbook to fully define contemporary versions of the concepts of supply and demand. Certain aspects of these terms are briefly reviewed here (Friedman 1962). The demand curve depicts the maximum price that a group of consumers will pay for the offered quantities. Therefore, one should think of the demand curve as dividing the plane into two regions. The first (which lies between the demand curve and the two axes) is a set of attainable price-quantity combinations. The second (which lies above and to the right of the demand curve) is unattainable in the sense that consumers will not pay the higher prices for these larger quantities.

The demand curve is defined for some fixed period of adjustment between the various points on the curve. The larger the period of adjustment, the flatter (more elastic) the demand curve. The elasticity of the demand curve is usually thought of as reflecting the number of close substitutes available in the market place for the good in question; the more close substitutes, the flatter the demand curve. The demand curve usually depicts a rate of purchase (tires purchased per week, month, or year). Certain items, however, such as paintings by artists who are no longer living, are relatively fixed in supply. In these cases, the demand curve does not have a time dimension and is called a stock demand curve.

Though demand curves almost always have a negative slope, this fact cannot be deduced from first principles (such as the utility maximization hypothesis). They invariably slope downward because a fall in price makes purchasing substitutes less attractive (the substitution effect) and increases the real income of consumers (the income effect). Both effects operate in concert to give the demand curve its downward slope.

Supply curve. The usefulness of the supply-demand framework stems from the fact that the social forces that shift demand curves often have a negligible effect on the supply curve (and vice versa). The supply curve depicts the maximum quantity that will be forthcoming at the designated price. Hence one should also think of the supply curve as dividing the plane into attainable and unattainable areas. Again, the specification of time for both the rate of production (output per day, week, month, or year) and the period of adjustment allowed for the suppliers to respond to different prices is a critical determinant of the shape of the curve.

The supply curve usually has an upward slope, though exceptions to this rule are more important than (the corresponding exceptions) for the demand curve. A negatively sloping supply curve may be a consequence of downward sloping supply curves for the individual firms. In this case, the industry may become dominated by the most efficient firm (a monopoly will eventually control output and price). If the supply (marginal cost) curves of the individual firms are upward-sloping, and the negative slope of the industry supply curve reflects economic forces that are external to the individual firms, then the competitive output and price will not be socially efficient. But the industry will tend to be competitive; there are no obvious forces that will cause one firm to control output.

Production frontier. This is a concave curve that depicts the technologically determined (variation in the) rate of trade-off between goods A and B that society faces. This curve shifts with changes in society's resource endowment.

Aggregate production possibility set. Given a fixed, finite level of resources, society can produce only finite amounts of any good or finite bundles of goods and services. The specification of the relation between available inputs and attainable outputs designates the aggregate production possibility set.

LITERATURE CITED IN THE INTRODUCTION

Clawson, M., and J.L. Knetsch. 1966. Economics of outdoor recreation. Johns Hopkins University Press, Baltimore, MD. 348 pp.

Friedman, M. 1962. Price theory: a provisional text. Aldine Publishing Company, Chicago, IL. 285 pp.

Hicks, J.R. 1943. The four consumer surpluses. Review of Economic Studies 11(1):31-41.

Houthaker, H.S. 1952. Compensated changes in quantities and qualities consumed. Review of Economic Studies 19(3):155-161.

Just, E.J., D.L. Hueth, and A. Schmitz. 1982. Applied welfare economics and public policy. Prentice-Hall, Inc., Englewood Cliffs, NJ. 491 pp.

Loomis, J.B. 1987. The economic value of instream flow: a review of methodology and benefit estimates. Journal of Environmental Management 24(2):169-179.

Marshall, A. 1920. Principles of economics, 8th ed. MacMillan and Co., Ltd., London. 713 pp.

McKean, J.R., and R.G. Walsh. 1986. Neoclassical foundations for nonmarket benefits estimation. Natural Resource Modeling 1:153-170.

Samples, K.C., and R.C. Bishop. 1985. Estimating the value of variations in anglers' success rates: an application of the multiple-site travel cost method. Marine Resource Economics 2(1):55-73.

Thayer, M.A. 1981. Contingent valuation techniques for assessing environmental impacts: further evidence. Journal of Environmental Economics and Management 8:27-44.

BIBLIOGRAPHY

1. Beardsley, W. 1970. Economic value of recreation benefits determined by three methods. USDA, Forest Service Research Note RM-176. 4 pp.

This is an interesting and useful commentary on the fact that the value of any given economic good or service varies with the market structure of the industry supplying that particular good or service. The author estimates the value of a visitor-day for recreationists using a 7-mile portion of the Cache la Poudre River in Northern Colorado; the particular site was in the Roosevelt

National Forest, about 50 miles from Fort Collins. The author estimated a "consumer's surplus" and "monopoly revenue" value for visitor-days based on travel cost data that was gathered from on-site questionnaires. He also estimated a "willingness-to-pay" for visitor-days through information obtained from a bidding game survey instrument, which was also administered on the site.

The paper is condensed, and some details are missing; thus, there is no mention of whether the bidding game was open-ended or closed. Important details underlying the calculation of consumer's surplus and monopoly revenue are missing. The TCM (travel cost method) data can be used to generate a demand curve and a calculation of consumer's surplus; but the monopoly revenue calculation requires additional assumptions or information on marginal cost. In the consumer's surplus calculation, the area between the demand curve and the horizontal line that intersects the mean travel cost is often taken as a measure of consumer's surplus. In this case, because there is no explicit mention of costs, consumer's surplus might be the entire area beneath the demand curve. The corresponding assumption for the calculation of monopoly revenue would set marginal cost to zero for all levels of output, and then maximize revenue by setting marginal revenue equal to zero; this gives the optimum output, and the net-revenue-maximizing price can then be chosen from the demand curve.

Willingness-to-pay was estimated as a value net of travel costs; the three methods for estimating the value of a visitor-day all yielded estimates that were close to $1.00. The number of visitor days which are demanded varies with market structure. Thus, 11,907 visitor-days were estimated for (the zero price entry fee) consumer surplus, while only 4,321 visitor-days would be demanded from a net-revenue-maximizing monopolist. It is not surprising that net willingness-to-pay over and above travel costs provided an estimate of only 4,803 visitor-day's demanded.

2. Cicchetti, C.J., R.K. Davis, S.H. Hanke, and R.H. Haveman. 1973. Evaluating Federal water projects: a critique of proposed standards. Science 181:723-726.

This paper addresses the issue of the application of cost-benefit criteria for the use of water resources, including the lacustrine and riverine resources of the United States. The authors assert that the Principles and Standards for Planning Water and Related Land Resources of the Water Resources Council makes several misapplications of economic analysis. The authors think that the development of a separate regional economic impact account for water projects will lead to an asymmetric double accounting of costs and benefits. That is, benefits are likely to be counted in both the national and regional accounts, and costs are likely to be considered in only the regional accounts. This will tend to foster the development of large, costly projects.

They fault the Principles and Standards for not delineating the shortcomings and pitfalls associated with the three proposed methods of measuring benefits (willingness-to-pay, net income, and least-cost). Of course the least-cost method for choosing the best method of providing some

public good or service is not a measure of benefits, but of costs, and if the project cannot pay its way, construction of the project will be economically inefficient even if the method selected is one that provides the good or service more cheaply than any other alternative. Net income approaches must take account of subsidized inputs; willingness-to-pay is often misapplied precisely because it is used without due consideration to the least-cost criteria.

The authors also note that cost-sharing (between the Federal agencies and local or regional agencies) procedures often affect the selection and implementation of projects. Hence cost-sharing aspects of proposed projects should be subjected to the same scrutiny, as say, the use of a discount rate. And, once again, the authors are highly critical of the Principles and Standards for advocating usage of below market value discount rates. This will also tend to encourage the development of large, costly water resource projects, and ignores the fact that Federal investment projects often displace private investment projects.

3. Knetsch, J.L. 1974. Outdoor recreation and water resources planning. Publication No. 3 of the Water Resources Monograph Series of the American Geophysical Union, Washington, DC. 121 pp.

Although this monograph is rather short, it is, in effect, an excellent introductory textbook on the economics and econometrics of water-resource-based-recreation economic analysis. The author develops the analysis and model building in conjunction with data taken from specific development projects. Unfortunately, the bulk of the examples deal with reservoir recreation sites rather than instream flow issues. Thus the intense competition for water resources, which is an integral part of instream flow conflicts and negotiations, is not explicit in this analysis. However, the practical, thorough, and comprehensible discussion of the problems and difficulties associated with using econometric (travel cost method) models to predict usage or demand levels and estimate net benefits for water-based recreation resources make this a useful reference.

The author's discussion of misinterpretations of on- (and off-) site data gathered to estimate demand and benefits for water-based recreation sites contains numerous examples. Three of these can be mentioned here: (1) many government agencies have mistakenly estimated usage levels as a function of various parameters, although they really intended to estimate demand curves; (2) agencies will estimate a demand curve for a recreation site and also the point at which the curve intercepts the quantity axis. A common error that occurs when the quantity units are participation-days consists of multiplying the intercept number of participation-days by the (variable) costs of providing a participation-day, in order to develop a total cost estimate, thereby inextricably confounding supply and demand because marginal cost is determined entirely by supply conditions and is independent of the demand curve; and (3) it is tempting to neglect the time variable when estimating demand curves by the travel cost method; however, if only the money cost variable is included, total net benefits (the area under the demand curve) will be underestimated.

4. Munley, V.G., and V.K. Smith. 1976. Learning-by-doing and experience: the case of whitewater recreation. Land Economics 52(4):545-553.

The authors reformulate the theory of household demand to account for the possibility of learning and experience augmenting effects on the demand for recreation activities. This reformulation is important and interesting, despite the inability of the authors to test this hypothesis on their estimates of willingness-to-pay for whitewater boating activity on the upper Lehigh River in the Pocono Mountains of Eastern Pennsylvania.

5. Gunn, C.A. 1977. Urban rivers as recreation resources. Pages 19-26 in Proceedings Symposium: River Recreation Management and Research. USDA Forest Service General Technical Report NC-28, North Central Forest Experiment Station.

This is one of a number of interesting papers that were given at a symposium that was sponsored by the North Central Forest Experiment Station of the U.S. Forest Service and the Backcountry River Recreation Management Research Project. The use of instream flows to enhance riverfront landscapes aesthetically and as a recreational amenity resource requires coordinated multiagency planning and evaluation. Most of the papers in this volume discuss planning problems, but give relatively scant attention to the problem of valuing instream flows relative to competing uses of stream flows. This paper falls in this category, but it does a good job of defining some of the alternatives that could be produced by various development plans. Thus, ribbon-type development plans and projects treat a waterway as a parkway that has carefully spaced facilities along its entire length; the node type of development project provides an appropriately located single concentrated land-water interface. The San Antonio River Walk illustrates the node type; the City of Wichita has implemented a ribbon type development project along the Arkansas and Little Arkansas Rivers. There is no formal economic analysis here, but this paper reminds us that instream flows have important urban multiplier income and employment effects, and that the withdrawal of streamflows for irrigation purposes can involve a transfer of income from urban residents to rural residents and farmers.

6. Hasen, V. 1977. Industry responds to the explosion in river recreation. Pages 38-44 in Proceedings Symposium: River Recreation Management and Research. USDA Forest Service General Technical Report NC-28, North Central Forest Experiment Station.

There is no formal economic analysis in this paper, but by citing a large number of locales and instances in which firms supplying recreational equipment for river use have undergone sizeable increases in output and employment, the author underlines the fact that the indirect economic effects associated with instream flows can be quite sizeable. Quantitative research on these effects should include estimation of employment and income effects from augmented demand for restaurant and lodging facilities, expenditures for fishing equipment that will be used for freshwater sport fishing in rivers and streams, and expenditures for other types of recreational equipment, such as cameras. The

author provides a qualitative assessment of the impact that recent dramatic increases in recreational use of rivers has had on small manufacturers of rafts, boats, and canoes, and on small firms that give guided tours of rivers. The employment multiplier effects cited here might be small if one uses a national rather than a local scale as a measuring stick; but water allocation issues are usually local or regional.

7. Heberlein, T.A. 1977. Density, crowding, and satisfaction: sociological studies for determining carrying capacities. Pages 67-76 in Proceedings Symposium: River Recreation Management and Research. USDA Forest Service General Technical Report NC-28, North Central Forest Experiment Station.

The author criticizes the assumption that wilderness and rural scenic sites offer an experience to visitors that is diminished by on-site congestion. Such congestion effects have been discussed in the literature on willingness-to-pay (see references 19 and 22 for conflicting views on this subject), but they could be detected and measured through the use of travel cost data. However, the models of crowding that he offers as a substitute for the economists' model, in which the quality of the experience declines with increasing numbers, of encounters, are little more than refinements and adaptations of this concept.

His most interesting qualitative criticism of the simplistic "encounter" model is that the expected level of congestion is a filtering agent that tends to discourage people from visiting the site in question if they desire a much larger number of encounters or a much lower number of encounters. The author examines some interesting data that tends to support this premise.

8. King, D.A. 1977. Economic evaluation of alternative uses of rivers. Pages 60-66 in Proceedings Symposium: River Recreation Management and Research. USDA Forest Service General Technical Report NC-28, North Central Forest Experiment Station.

This interesting paper quickly sketches the cost-benefit framework that should be used for assessing the efficient allocation of natural resources. Both the appropriate interpretation and econometric implementation of these models are reviewed. However, there is no discussion of the use of survey techniques to estimate off-site benefits. There is a brief discussion of the alternative cost concept, and the use of a technique that has been proposed to estimate the rate of increase in the net benefits provided by natural resources that supply recreation benefits. Some economists would assert that since this paper was written, considerable progress in assessing and measuring off-site recreation benefits has been made, but many economists doubtless still believe that measurement of these benefits cannot be made operational.

9. Lewis, E.D., and G.G. Marsh. 1977. Problems resulting from the increased recreational use of rivers in the West. Pages 27-31 in Proceedings Symposium: River Recreation Management and Research. USDA Forest Service General Technical Report NC-28, North Central Forest Experiment Station.

This paper discusses management problems associated with the large increase in recreational usage of rivers in the American West. These problems include safety, fire control, garbage disposal, permit fees, impacts on vegetation and wildlife, enforcement of rules and regulations, determination of carrying capacity, and resolution of user conflicts. All of these problems have been greatly magnified by the recent explosion of recreational activity on Western rivers. There is no economic analysis in this paper, but the authors point out that any human activity that lowers flow levels also lowers the value and quantity of this recreational resource.

10. Milhous, R.T. 1977. Water supply versus recreation and the fishery-minimum stream flows. Paper No. 4-5, American Water Works Association 97th Annual Conference Proceedings, Anaheim, CA. 22 pp.

This paper deals with the problem of the optimal allocation of water resources within a broad cost-benefit framework. Allocations of water to conflicting uses should utilize the basic principle that marginal net benefits to every usage should be equal. This principle is difficult to implement for water management because of stochastic variations in flow, the absence of market prices for certain outputs, and the fact the some of the costs of certain low (or high) flows are distributed over time (such as the loss of a fishery due to dewatering or a very low average daily flow for a month) and certain costs and benefits are instantaneous. The author examines the role of this principle in the actual allocation of water flows when municipal or industrial uses conflict with fisheries and recreation needs in three case histories: the Tuolumne River below O'Shaughnessy Dam in California, the diversion of western slope stream waters by the county and City of Denver in Colorado, and the use of Cedar River water by the City of Seattle in Washington. This paper contains a brief history of instream flow legislation and attempts to quantify instream flow fishery and recreation needs.

11. Whittlesey, N., and G.H. Pfeiffer. 1977. Economic analysis of methods for controlling pollution from irrigation return flows. Paper presented at Conference on Regional Irrigation Water Quality Control, Boise, ID. 14 pp. (Available from Dr. N. Whittlesey, Dept. of Agricultural Economics, Washington State University, Pullman, WA 99164-6210).

This paper studies the impact of five policy alternatives for controlling nitrogen pollution, sediment loss, and water temperature in rivers that receive large amounts of irrigation runoff in the Yakima River Basin of eastern Washington. The authors use a hydrology model and a linear programming model of farm output to quantify the water quality and farm output impacts of the various policy alternatives. The alternatives include physical reductions in the quantity of available irrigation water, a tax on nitrogen fertilizers, the

imposition of a (per acre-foot) charge on irrigation water usage, and various combinations of these three alternatives. All three alternatives improve river water quality, but they differ in their impact on farm income and output.

12. Daubert, J.T., R.A. Young, and S.L. Gray. 1979. Economic benefits from instream flow in a Colorado mountain stream. Completion Report No. 91. Department of Agricultural and Natural Resource Economics, Colorado State University, Fort Collins, CO. 149 pp.

This paper reports the first effort to value recreational benefits from instream flows. The authors use a survey instrument to relate instream flows to benefits for three recreational activities on the Cache la Poudre River, including whitewater rafting, fishing, and shoreline activity. Respondents were shown color photographs of eight different stream flow levels at four different sites so that they readily grasped the significance of the questions. The valuation technique is partially disguised in that the participants were asked to relate entrance fees and sales taxes to instream flows. The authors used a standard-single equation regression to test the hypothesis that, holding socio-economic variables constant, bid size is a function of the level of streamflow.

The authors found that the marginal benefit of a unit of streamflow for whitewater rafters was (roughly) a constant, but marginal benefits for fishermen reached a maximum value at 50 cfs (cubic feet per second) and declined to zero at 500 cfs. Fishermen had a remarkably accurate grasp of the streamflow levels corresponding to the photographs. Marginal benefits declined to zero at 750 cfs for shoreline activities, but the marginal benefits (versus streamflow) curve was lower and flatter for shoreline activities than for angling. Shoreline activities was a high-attendance, low-value use. Angling was a low-attendance, high-value use.

The area under the marginal benefits curve for any flow level and each activity corresponds to the total benefits conferred by the flow level for that activity. Summing over the activities gives the total instream flow marginal (recreation) benefits curve. The area under this curve gives the total instream flow (recreation) benefits.

The individual (recreation activities) and total recreation benefits versus flow curve can be used to distinguish between flow levels at which diversions of instream flows are complementary with recreation activities. In the spring, fishing and irrigation complement each other. In the early fall and late summer, angling activity and irrigation outputs are substitutes.

For the lowest flow (50 cfs or less), the (gross) instream flow value for fishing experiences is $26.38 per cfs-day. Marginal instream flow units for whitewater rafting are worth about $9.95. Income, age, education, and years of recreational experience were statistically significant (linear variables) in explaining bid size. Sex, occupation, and size of the previous city of residence were also statistically significant explanatory (dummy) variables of bid size.

13. King, D.A. 1979. User-based assessments of the value of fish and wildlife resources. Pages 44-46 in Assessing Amenity Resource Values, General Technical Report RM-68. Rocky Mountain Forest and Range Experiment Station, USDA, Forest Service.

This paper discusses refinements of the travel cost method used to estimate the demand for riverine recreation sites in Cave Creek Canyon in the Chiricahua Mountains of southeastern Arizona. This area is in the Coronado National Forest. The demand for trout fishing on the White Mountain Apache Reservation is also studied and estimated. Only the survey design and the analytic and econometric techniques for analyzing the data are discussed in this paper; the empirical results are presented in reference 46.

In this project, the author uses questionnaire and survey techniques to study the process of preference formation, and data on household preferences (in place of the usual socio-economic variables), in estimating demand for these wildland and recreation resources. The statistical techniques are complex, but innovative.

14 Lamb, B.L. 1979. Instream uses and recreation value of water. Pages 41-47 in Proceedings of the Twenty-fourth Annual New Mexico Water Conference. New Mexico Water Resources Research Institute, Las Cruces, NM.

This paper does not treat, in a formal way, the recreational values of instream flows. It does point out that when instream flows are preserved for public benefits, some specific private or public entity must actually preserve these flows. The resulting allocation of water resources will, in general, not be independent of the legal-institutional framework that has been used to preserve the flows. Economists have recognized the role of transactions costs in creating (in-) efficiencies for a barter allocation solution in which a government agency (or set of agencies) represents public recreation interests. The author points out that ideological pressures underlie the allocation process, the institutional framework used to define and preserve instream flows, and the designation of a set of agencies that implement the preservation of instream flows. Of course, these ideological constraints would be difficult for economists to analyze or model. The author fails to mention that the rapidly increasing demand for riverine recreation resources is one of the principal factors causing change in the allocation of water resources.

15. Aiken, J.D. 1980. Interrelationships between water allocation and water quality management policies. University of Nebraska, Department of Agricultural Economics Staff Paper No. 5. Lincoln. 9 pp.

The author points out that maintenance of ground water stocks and free-flowing streams and rivers ameliorates water quality problems.

16. Milhous, R.T., and W.J. Grenney. 1980. The quantification and reservation of instream flows. Progress in Water Technology 13:129-154.

This presentation is similar to the discussion in reference 10. The concept of instream flow as a basic factor input for any society's aggregate production possibility set is introduced. Waste elimination, stream recreation activities, and hydro-power are but three economic outputs that utilize instream flow as a factor input. In particular, the PHABSIM method is discussed for evaluating the available recreation area in a reach of stream as a function of the level of discharge, velocity, depth, width, and other characteristics of the flow. Except for a brief discussion on the early history of instream flow legislation, the interesting economic implications of the technological information that PHABSIM makes available are not developed as fully here as in other publications by Milhous (see references 10, 32, and 35).

17. Ranquist, H.A. 1980. Res judicata--will it stop instream flows from being the wave of the future? Natural Resources Journal 20(1):121-151.

The appropriation doctrine of the arid western United States has affected both the allocation of water resources and the pattern of output of final goods and services. The simplicity and workability of the doctrine has been supplemented by various legal doctrines that have arisen in the water rights legal arena. The doctrines of "res judicata" and "collateral estoppel" discussed in this paper have limited the possibilities for litigation in fully appropriated streams, particularly when water rights in a stream have been previously adjudicated. However, the acquisition of instream flow rights by government agencies or private individuals will, at times, require litigation in fully appropriated streams.

The author discusses rivers in which tremendous wastage by agricultural diverters occurs in both the transport and use of irrigation waters. The use of the most effective available technology (drip sprinklers) would greatly enhance return flows, thereby opening up the possibility of acquisition of significant instream flow rights. The issue of wastage on this scale raises the critical institutional-economic issue of whether water rights can be limited to truly economically beneficial uses under the appropriation doctrine. The author believes that the appropriation doctrine can be used in this fashion. But he also believes that in many States, legislation will be needed to smooth the way for the acquisition of instream flow rights.

18. Walsh, R.G. 1980. Empirical application of a model for estimating the recreation value of water in reservoirs compared to instream flow. Completion Report No. 103. Colorado Water Research Institute, Fort Collins, CO. 50 pp.

The contingent valuation method was used to estimate willingness-to-pay for recreational angling activity at three high mountain reservoirs and three high altitude riverine fishing sites in western Colorado in 1978. The study sites varied significantly in size and distance from metropolitan Denver. The

sample size was 130 fishermen. A stepwise regression procedure was used to estimate the relation between bid size (the dependent variable) and income, congestion (encounters per day), substitution effects, total fishing days (engaged in during the season), and travel distance.

Holding other variables constant, benefits declined from \$20/day (for zero encounters) to zero when 30 other persons were encountered during the day. The sites are currently overutilized. Current usage levels are roughly 50% greater than the optimum for reservoirs and 20% greater than the optimum for rivers.

Adjusting for congestion, Walsh estimates the average consumer surplus benefit of reservoir fishing to be about \$10.26 per day at optimum usage levels, but it is \$11.78 per day for river fishing at optimum capacity levels. These benefits estimates fall to \$7 (reservoirs) and \$10.53 (rivers) at current usage levels. That is, providing access to 33% more high mountain reservoirs would increase existing reservoir fishing benefits by \$3.77 per user day. Providing access to 15% more river miles for fishing would increase existing river fishing benefits by \$1.25 per day.

Walsh asserts that many Colorado irrigation companies fill high mountain reservoirs in the fall and wait until the following spring to fill reservoirs in the plains. He believes that total benefits would increase if storage in high mountain reservoirs began in May and continued through early July, when instream flow levels in Colorado rivers approach maximum discharge levels and reduction of streamflows would increase fishing benefits. In the fall, streamflows could be used to fill plains reservoirs and augment fishing benefits.

19. Walsh, R.G., R.K. Ericson, D.J. Argosteguy, and M.P. Hansen. 1980. An empirical application of a model for estimating the recreation value of instream flow. Completion Report No. 101. Colorado Water Resources Research Institute, Colorado State University, Fort Collins, CO. 66 pp.

The authors use a combination of travel cost data obtained from on-site surveys and willingness-to-pay information (obtained in conjunction with the travel cost data) to estimate willingness-to-pay as a net value for various cold-water stream recreation benefits and activities including fishing, kayaking, and rafting. The surveys were conducted on nine Colorado western slope river sites. The questionnaire elicited information on willingness-to-pay in relation to instream flow, congestion, socio-economic characteristics of participants, and management costs.

The inclusion of congestion effects as an independent explanatory variable of willingness-to-pay and net benefits is seminal. The authors suggest that omission of this variable led Daubert, Young, and Grey (reference 12) to underestimate the aggregate net benefits of on-site recreation on the Cache la Poudre River in Northern Colorado. The authors found that the average net willingess-to-pay is about \$20/day for the fishing activity when a fisherman encounters no one, but falls to zero when the same fisherman encounters about 30 other site users.

20. Butcher, W.R. 1981. How can an economist contribute to better choices in water allocation? Pages 58-67 in Economic issues in the competition for Columbia River basin water. Economics Committee of the Pacific Northwest River Basin Commission, Columbia River, Vancouver, WA 98660.

The author examines the potential contributions of economists in improving the existing allocation of water resources. He suggests that economists should look more closely at the allocation of water resources, and focus less attention on the evaluation of water development projects through the use of cost-benefit criteria. The author thinks that the advocacy of marginal pricing for water development projects is a worthwhile endeavor, but Butcher also believes that economists and resource managers should become more deeply involved in assessing distributional issues that arise from water allocation problems.

21. Cleary, R.E. 1981. Economics and fish. Pages 36-44 in Economic issues in the competition for Columbia River basin water. Economics Committee of the Pacific Northwest River Basin Commission, Columbia River, Vancouver, WA 98660.

This paper combines a detailed examination of the impact of river development on Columbia River fisheries with a critical discussion of the techniques used by economists to value trade-offs between fisheries and river development projects. Columbia River fisheries have been adversely impacted by the blocking and impounding of flowing water and resulting loss of spawning habitat, flow diversions for out-of-river uses, and power generation projects. It is difficult to assess the ecologically interrelated impacts of these water uses on fisheries; however, the author suggests that quantification of these ecological impacts is a desirable and feasible goal for ecologists and economists.

22. Daubert, J.T., and R.A. Young. 1981. Recreational demands for maintaining instream flows: a contingent valuation approach. American Journal of Agricultural Economics 63(4):666-676.

This paper is essentially the published version of the Cache la Poudre River study by Daubert, Young, and Grey (reference 12). This study does differ from the earlier paper, however, in that (following Walsh et al. 19) the authors explicity consider congestion effects. They find that the willingness-to-pay estimates are unaffected by the actual degree of congestion. This is interesting in that the Cache la Poudre is one of the most heavily used (for recreational and fishing purposes) rivers in the United States.

23. Haas, W.T. 1981. Regional decision making--an interstate perspective. Pages 45-48 in Economic issues in the competition for Columbia River basin water. Economics Committee of the Pacific Northwest River Basin Commission, Columbia River, Vancouver, WA 98660.

The author states that nonmarket economic values (including the recreational, aesthetic, and wildlife habitat values provided by instream flows) need to be given greater weight in water allocation decisions at the regional level. He also advocates the greater use of regional water markets whenever feasible, and an examination of State water laws to make sure that they are compatible with changing market conditions and evolving market institutions. Haas thinks that too many State agencies are involved in making overly narrow cost-benefit studies of water development projects.

24. Katz, M.B. 1981. The Regional Power Act: an institutional innovation in decision making. Pages 49-57 in Economic issues in the competition for Columbia River basin water. Economics Committee of the Pacific Northwest River Basin Commission, Columbia River, Vancouver, WA 98660.

The author assesses the economic and social impacts of the Federal Regional Power Act that President Carter signed into law on December 5, 1980. There are three key provisions to the bill. First, the Bonneville Power Authority (BPA) must offer to meet the firm power loads of any Pacific Northwest utility or direct service customer in the region. Second, investor-owned utilities may offer for sale to BPA an amount of power equivalent to their sales to residential and small farm customers; BPA will (re)sell that same amount of power to those utilities at a lower cost. Third, the act requires that fish and wildlife resources in the Columbia River and its tributaries must be protected, enhanced, and mitigated. The act attempts to facilitate efficient hydro-power allocation in a region of growing energy deficits.

25. Kelso, M.M. 1981. Economic analysis in river basin policy making. Pages 68-77 in Economic issues in the competition for Columbia River basin water. Economics Committee of the Pacific Northwest River Basin Commission, Columbia River, Vancouver, WA 98660.

Kelso argues that the usefulness of economics in providing policy prescriptions for the efficient allocation of resources is overly restricted by the tendency of economists to mimic and emulate the natural sciences rather than disciplines such as law and architecture which accept their dependence on the value systems of the practitioners in a much less restrained fashion. He believes that economists need to spend a good deal of time and effort in quantifying nonmarket, normative economic values as they pertain to certain specific policy issues. These include the allocation of public goods, nonmarket outputs of natural resources, the size distribution of income, and intergenerational allocation and distribution issues. He admits that economists have done some important research in quantifying values that pertain to the allocation of nonmarket outputs. He believes, however, that research in all of these areas has been stultified by the tendency of social scientists to emulate natural scientists.

26. McKusiak, R.B. 1981. Irrigated agriculture in the Pacific Northwest. Pages 28-37 in Economic issues in the competition for Columbia River basin water. Economics Committee of the Pacific Northwest River Basin Commission, Columbia River, Vancouver, WA 98660.

The author discusses a price-endogenous linear programming model of the Pacific Northwest region. The model includes 19 livestock and crop products of the Pacific Northwest, transportation costs, and resource constraints (for land, water, and labor). The demand for agricultural output includes regional, national, and export components. The objective function is the sum of producers and consumers surplus. McKusiak uses the model to examine various structural specifications in the growth in demand for agricultural output in the year 2000. These include a high export, a high irrigated cropland, and a high cost factor input (increasing energy and labor cost) scenario.

27. Sale, M.J. 1981. Optimization techniques for instream flow allocations. Ph.D. Thesis. University of Illinois, Champaign-Urbana. 175 pp.

The author develops a stochastic programming model for multiple purpose reservoirs, in which the instream flow needs of downstream fisheries are incorporated into the objective function. These needs are quantified by an index of weighted usable area. Weighted usable area is one of the outputs of PHABSIM, an approach for quantifying aquatic habitat that was developed by the Aquatic Systems Branch of the National Ecology Research Center of the U.S. Fish and Wildlife Service.

28. Waltenbaugh, G. 1981. Forum introduction. Pages 2-5 in Economic issues in the competition for Columbia River basin water. Economics Committee of the Pacific Northwest River Basin Commission, Columbia River, Vancouver, WA 98660.

This short paper discusses the role of the Pacific Northwest River Basin Commission (PNRBC) in the allocation of riverine water resources in the Columbia River Basin. The commission is composed of 11 Federal and 5 State official members, and 2 official observers (1 Canadian, 1 from the Northwest Indian tribes). The commission deals primarily with long-range planning, priority assessment, and analysis of regional water allocation issues.

The author asserts that the three major uses of Columbia River Basin riverine water resources are for irrigated agriculture, hydro-power, and aquatic habitat for key commercial and sport fish species. The demand for these uses will grow rapidly in the near future, primarily due to regional and world population growth. The need to balance market and nonmarket outputs in the face of growing demands and fixed energy and water resource supplies make the work of the commission critical and difficult.

29. Whittlesey, N.K., and R.G. Kraynick. 1981. The Columbia River is a common resource. Pages 6-17 in Economic issues in the competition for Columbia River basin water. Economics Committee of the Pacific Northwest River Basin Commission, Columbia River, Vancouver, WA 98660.

This paper applies the basic framework of environmental economics to the problem of allocating river and water flows to recreational, hydropower, and irrigation uses. The discussion deals with market failure in public goods, nonmarket allocations of common resource properties, the role of property rights in the market allocation of river flows, the implications of transaction costs for river water resource allocations, and the irreversibility of certain natural environment policies and resource allocations. This discussion is distinguished by the sharp application of broad economic analyses to specific allocation problems in the Columbia River Basin.

30. Wilkins, J.R. 1981. Economics issues in competition for Columbia River water hydropower. Pages 18-27 in Economic issues in the competition for Columbia River basin water. Economics Committee of the Pacific Northwest River Basin Commission, Columbia River, Vancouver, WA 98660.

This article examines the impact of power shortages and power pricing modes on economic growth in the Columbia River Basin. Power deficits affect various industries in differential fashion. Thus lost per annum wages and output in the food processing industry, per kilowatt-hour of power deficit, is $10.90; in the pulp and paper industry, $0.90; and in the aluminum industry, $0.07. Since the power deficit will grow steadily throughout the 1980's and 1990's, these ratios will be important determinants of the pattern of industrial output. Also, protection of fisheries with instream flows will sharply affect the demand for nonhydroelectric power, even in the Columbia River Basin.

31. Dodge, N.A. 1982. Columbia River Treaty: environmental impact. Journal of the Water Resources Planning and Management Division, American Society of Civil Engineers 198(WR3):309-320.

This paper documents the lowering of energy costs through the implementation of the Columbia River Treaty (1961); however, this has been achieved at substantial cost to salmonid fisheries.

32. Milhous, R.T. 1982. Quantifying instream values for water allocation. Pages 489-493 in F. Kilpatrick and D. Matchett, eds. Proceedings of the Conference on Water and Energy. American Society of Civil Engineers, New York.

This paper outlines the use of the PHABSIM method to construct what economists call production frontiers that describe technologically feasible combinations of riverine recreation outputs and, say, hydropower or irrigated crops. In the Terror River (located on Kodiak Island in Alaska) example discussed here, fishery habitat competes with hydropower for streamflow. The

PHABSIM method for measuring and quantifying the effective area available for recreation use as a function of stream velocity, depth, discharge, width, and other measurable characteristics (including channel roughness, cover type, and substrate type) is an important precursor of economic analysis of river development projects. The PHABSIM method takes account of the stochastic variation in streamflow, and hence the method can be exploited fully only by economic analyses that account for the stochastic nature of the benefits flow.

33. Sale, M.J., E.D. Brill, Jr., and E.E. Herricks. 1982. An approach to optimizing reservoir operation for downstream aquatic resources. Water Resources Research 18(4):705-713.

A stochastic programming model of reservoir operation is presented. The model uses weighted usable area to quantify biological instream flow requirements. The reservoirs are operated to meet a variety of socio-economic goals, including flood control, reservoir recreation, and economic efficiency. The author uses an example to show that changes in storage and release patterns can augment some goals without sacrificing others.

34. Brookshire, D.S., J.L. Merrill, and G.L. Watts. 1983. Economics and the determination of Indian reserved water rights. Natural Resources Journal 23:749-765.

This interesting article assesses the operational ambiguity surrounding the reserved rights doctrine when it is applied to Indian reservations. Legally, these differ from other water rights (under the appropriation doctrine) in three respects: (1) they may be created by legal acts that do not involve explicit consideration of water flows and rights; (2) they are not lost by nonuse; and (3) they are often senior to other rights, so other uses of river flows are contingent upon the magnitude of these rights. The U.S. Supreme Court has used an agricultural measure called practicably irrigable acres (PIA) to express a reasonable rule for quantifying Indian reserved water rights. The authors express grave doubts that this measure will ever be free of serious ambiguities as to its operational content, though they do believe that considerations of "arability, engineering feasibility, water supply, and economic feasibility" are germane and relevant to a finding that reservation lands are practicably irrigable. PIA may not be an equitable guide to Indian water rights in that it need not be based on tribal demands or some balancing of tribal benefits and benefits to other water rights owners and users. The authors concur strongly with recent court decisions that indicate that PIA should be used to quantify Indian reserved water rights in conjunction with other economic and social considerations.

35. Milhous, R.T. 1983. Instream flow values as a factor in water management. Pages 231-236 in R.J. Charbineau and B.P. Popkin, eds. Proceedings of Regional and State Water Resources Planning and Management, American Water Resources Association, Bethesda, MD.

This is an excellent discussion of the social and economic implications of the PHABSIM method for evaluation of stream and recreation area as a function of stream discharge, velocity, depth, and other hydrologic or channel characteristics. The author shows how PHABSIM output can be used to generate a production frontier that relates the technological trade-off between recreation outputs and other streamflow uses, including hydropower. This paper features the integration of an economic benefits function that relates the aggregate and individual net dollar benefits from various levels of streamflow for recreation participants on the Cache la Poudre River in Northern Colorado, to the technological data and constraints implicit in the PHABSIM output and engineering data on streamflow and hydropower generation. The author understands the value of both types of data in negotiating instream flow settlements.

There are a number of papers on PHABSIM by Milhous, but this one gives the most complete discussion of the economic implications of the outputs of this method.

36. Narayanan, R., D.T. Larson, A.B. Bishop, and P. Amirfathi. 1983. An economic evaluation of benefits and costs of maintaining instream flows. Water Resources Planning Series Paper No. UWRL/P-83/04, Utah Water Research Laboratory, Utah State University, Logan. 48 pp.

This paper discusses the costs and benefits of instream flows and consumptive withdrawals from rivers for irrigation purposes. Instream flows are valuable for aesthetic, recreational, and hydropower purposes, but this discussion focuses on recreational benefits. This paper is seminal in two respects: (1) it focuses on the opportunity costs of preserving instream flows as well as the benefits, and (2) it takes account of the stochastic nature of (expected) instream flows as well as the change in the value-maximizing pattern of agricultural output (with the magnitude of irrigation withdrawals) due to fluctuating levels of discharge. The analysis should be extended to a multiperiod planning horizon for certain aspects of the allocation problem, but this paper provides one of the best available guides to quantifying the concept of economically optimal instream flow policy. In particular, the modeling of the institutional constraints limiting water trades and sales (the appropriation doctrine) is brilliant and innovative.

37. Amirfathi, P. 1984. Estimation of costs and benefits of instream flow (optimization). Ph.D. Thesis. Utah State University, Logan. 148 pp.

The author uses the hedonic property method and data on participation rates and travel costs to three Utah river recreation sites to estimate empirical demand functions for the use of these sites. These demand functions

were combined with information from an on-site survey to estimate willingness-to-pay (above travel and other recreation related costs) for instream flow levels.

The social opportunity cost of providing these instream flows was estimated for various flow management regimes. The principal alternative use of the water is (for diversions) for irrigated agriculture. The imputed expected marginal value product of water in providing agricultural output is used as the social marginal opportunity cost of providing instream flows. However, this expected marginal value product is determined as an optimum shadow value in a programming model for maximizing the value of agricultural output, not its true market value.

38. Bowes, M.D., J.V. Krutilla, and P.B. Sherman. 1984. Forest management for increased timber and water yields. Water Resources Research 20(6):655-663.

The authors attempt to estimate the change in aggregate net social benefits that is generated by an increase in water yields from a vegetation management program in the subalpine zone of the northern Colorado Rockies. The vegetation management program consists of a series of cuts and thinnings in lodgepole pine stands. The authors admit that the relation between vegetation management and water yield is complex and difficult to quantify, but small clearcuts and thinnings will reduce transpiration and interception losses from the forest canopy, while augmenting the runoff from snowmelt.

The authors compare the pecuniary yield from the harvestable timber produced by the lodgepole pine management program to the pecuniary value of the augmented water yield. The value of the timber harvest will depend on the volume and the quality of the timber produced. The marginal value product of an acre-foot of water produced by the program will equal the marginal value product of streamflow in various consumptive and diversionary uses for the affected rivers and streams. Thus the authors find that if the program yields augmented western slope runoff, the marginal value product of an extra acre-foot of water will be less than if the augmented streamflow occurs as front range runoff. Front range water is more valuable than western slope water.

The authors impute a value for municipal-industrial, hydropower, and agricultural uses for both western slope and front range runoff. Of course the calculations rest heavily on the estimated net consumptive loss for each use category. They estimate that this varies from zero for hydropower, to 50% for agriculture, to 100% for municipal-industrial uses that involve interbasin transfers.

The low per-acre timber yields of the lodgepole pine stands will not cover construction costs for the roads needed to carry out the program at even a 4% discount rate. The net pecuniary value of the augmented water yield will cover road-building costs at a 4% discount rate, but the yield from the timber harvest and the yield from the augmented streamflow must be added together in order to cover road-building costs at a 7% discount rate.

Unfortunately, there is no discussion of the nonpecuniary benefits associated with the vegetation management program. The authors assert that there is probably no obvious impact on terrestrial habitat from the clearcuts. This is debatable, but the negative impact of the roads on large game habitat and hunting seems indisputable. Also, the effect of the augmented sediment in the runoff from the roads and the logging trucks on aquatic habitat will be negative. The overall impact on aquatic habitat may be negligible because the increased instream flows in certain stream reaches will increase aquatic habitat (although during mid-spring, when runoff reaches peaks, enhanced runoff may decrease habitat in certain stream reaches).

39. Cordell, H.K. 1984. Pricing river recreation: some issues and concerns. Pages 272-284 in J.S. Popadic, D.I. Butterfield, D.H. Anderson, and M.R. Popadic, eds. National river recreation symposium proceedings. Louisiana State University, U.S. Forest Service, National Park Service, and Bureau of Land Management.

The author shows, with data from the National Recreation Survey, that the level of participation in canoeing and kayaking is high for the lowest income groups, then falls with increasing income, and then begins to rise as income rises from blue collar to middle class levels. The heavy use of river recreation sites by low income recreationists creates some concern that widespread imposition of entrance fees will disproportionately affect low income users. Another concern of the authors is that commercial outfitters enjoy high profits; permit priority is granted to existing permit holders. The author discusses the gains in efficiency of replacing the seniority system with a competitive bidding system.

Cordell buttresses his discussion on the undesirable benefits redistribution effects of entrance fees with empirical studies that estimate travel cost method demand curves for the Upper Delaware and Middle Fork Salmon Rivers. Economic efficiency requires setting price (per person for a boating trip) equal to marginal cost. On the Upper Delaware this is $2.80; on the Middle Fork Salmon, demand is so great that an entrance fee of $145 for boating trips would be required to equate demand and supply. Due to the unique and widely appreciated nature of the resource, this entrance fee is much higher than the marginal cost (per visitor); to equate price to marginal cost and equate supply and demand would require the use of a non-price rationing scheme, such as a lottery.

40. Davoren, W.T., and J.E. Ayres. 1984. Past and pending decisions controlling San Francisco Bay and delta. Water Science Technology 16(3-4):667-676.

The authors point out that diversions, pumped exports, and impoundments of stream flows that feed the San Francisco Bay and delta have sharply impaired the biological productivity of this estuarine zone. No solutions to maintaining the quality and outputs of these waters are on the planning horizon, due to sharp agency and management objective conflicts.

41. Loomis, J.B., and G.L. Peterson. 1984. Economic information in river recreation management. Pages 260-271 in J.S. Popadic, D.I. Butterfield, D.H. Anderson, and M.R. Popadic, eds. National river recreation symposium proceedings. Louisiana State University, U.S. Forest Service, National Park Service, and Bureau of Land Management.

The authors sketch the role of (Marshallian and Hicksian) consumer surplus as a guide for cost-benefit studies. Monetary value can be used as a guide to changes in welfare when supply curves (or demand curves) shift in those situations in which changes in consumer's surplus are closely approximated by changes in market value. This will be the case in which there are large numbers of producers in highly competitive markets (hence supply curves are relatively elastic). This is not likely to be the case in which the goods are unique recreation resources; some measure of the area between the (site) demand curve and the marginal cost curve associated with maintaining the resource must be used to estimate net social benefits in such situations. The authors discuss a number of pitfalls associated with the estimation and interpretation of aggregate net willingess-to-pay.

42. Strauss, C.H. 1984. Scheduling whitewater boating usage on the Lehigh River. Pages 316-324 in J.S. Popadic, D.I. Butterfield, D.H. Anderson, and M.R. Popadic, eds. National river recreation symposium proceedings. Louisiana State University, U.S. Forest Service, National Park Service, and Bureau of Land Management.

The Penn State University School of Forestry was asked by the State of Pennsylvania to study use patterns by commercial and private boaters in a 24-mile stretch of the Lehigh River in Lehigh Gorge State Park. The study was conducted to determine the optimal timing of boat trips, recommendations for improving the system, environmental impacts from boating, and the optimal distribution of boating usage between private and commercial boaters. Willingness-to-pay and operating cost data could have been used to determine daily and seasonal entrance fees; however, all recommendations were based on time-motion study patterns and onsite inspections.

43. Walsh, R.G., L.D. Sanders, and J.B. Loomis. 1984. Measuring the economic benefits of proposed wild and scenic rivers. Pages 301-315 in J.S. Popadic, D.I. Butterfield, D.H. Anderson, and M.R. Popadic, eds. National river recreation symposium proceedings. Louisiana State University, U.S. Forest Service, National Park Service, and Bureau of Land Management.

In 1984, no rivers in Colorado were protected by State or Federal designation as recreational, wild, or scenic rivers. Protecting rivers under the Federal Wild and Scenic Rivers Act means that the selected rivers or certain sections of the selected rivers would be protected in their natural free-flowing condition. Further construction of dams, reservoirs, water diversions, and other development incompatible with the natural free-flowing condition would be prohibited. Existing multiple uses, including fishing, boating, hunting, hiking, camping, sightseeing, livestock grazing, watershed protection, and timber harvesting would continue with the provision that the natural state of the rivers remain protected.

Eleven rivers were recently studied by Federal agencies and found suitable for protection by State or Federal designation as recreational, wild, or scenic rivers. These 11 rivers represent about 4.5% of the total miles of rivers in the State. The authors try to develop information on the economic benefits of preservation through the use of contingent valuation methods survey data. Their survey instruments were designed to estimate consumer surplus from annual (current year) recreation use, options benefits (or "insurance" benefits; this is particularly relevant when the resources are unique or losses due to development are irreversible), existence values, and bequest values. Also, the willingness-to-pay questions referred to varying degrees of protection. The results of this study show that the benefits from preservation are high; the present value from protecting the three most valuable rivers in the State (Cache la Poudre, Elk, and Colorado) is $598 million. Present values of protection benefits increase with the number of rivers protected, but at a decreasing rate; the social costs of protection increase at an increasing rate. The optimal number of rivers to be protected is determined by equating the marginal social benefits of protection to the marginal social cost (including opportunity costs) of protection. This occurs when 15 rivers (those originally studied plus four others) are protected.

44. Ward, F.A. 1984. Optimally managing wild rivers for instream benefits. Pages 285-300 _in_ J.S. Popadic, D.I. Butterfield, D.H. Anderson, and M.R. Popadic, eds. National river recreation symposium proceedings. Louisiana State University, U.S. Forest Service, National Park Service, and Bureau of Land Management.

This interesting paper uses travel cost data for a reach of the Rio Chama River between the El Vado and Abiquiu Reservoirs in New Mexico to estimate a recreation demand for instream flows. The relevant activities include white-water boating (rafting, kayaking, and canoeing) and angling. The travel cost data were developed from a travel cost survey instrument that included questions on travel costs, income, and assorted socio-economic variables; a question on flow levels (seven different flows were specified) was included in the questionnaire. Separate demand equations were estimated for each flow.

The stochastic nature of the flow regime was incorporated in a dynamic programming model in which the flow release policy (from City of Albuquerque reservoirs) was the decision variable. The model incorporated the information embodied in the seven demand equations. Currently, Albuquerque releases water during the winter months, when recreation demands and evaporation losses are low. Summer releases entail larger evaporation losses, but increase the _gross_ value of the flow by about $1,100 per acre-foot; the increased evaporation losses are unknown, and $40 per acre-foot is used as a representative value; hence the potential increase in _net_ benefits (due to recreation activity) is $1,060.

45. Amirfathi, P., R. Narayanan, A.B. Bishop, and D. Larson. 1985. A method for estimating instream flow values for recreation. Water Resources Planning Series Paper No. UWRL/P-85/01, Utah Water Reseach Laboratory, Utah State University, Logan. 66 pp.

This is a seminal study on the demand for instream flows. The study sites are located on parts of the Blacksmith Fork and the Little Bear Rivers of the southwest portion of Cache County of Northern Utah, and a portion of the Logan River, which flows through Northern Utah. The Blacksmith Fork joins the Logan, and the Bear River has a confluence with the resulting tributary formed by the Blacksmith Fork and the Logan.

The authors use the household production function approach to estimate a demand for instream flows. Thus the estimated demand curve is of the hedonic property category. The great advantage of this technique is that, when used properly, it utilizes the prices and expenditures on all recreation related items. The survey instruments elicited responses relating willingness-to-pay and stream flows. The surveys were taken on the camp sites during 1982, which was a year with unusually high flows.

An elegant mathematical treatment of the household production theory to derive "full prices" for recreation goods and activities is followed by an equally stimulating presentation of the use of generalized least squares to estimate seemingly unrelated demand equations for on-site visits to the three sites. These multivariate demand equations did not use streamflow as an independent variable. Willingness-to-pay, net benefits, and streamflow were related through a single-variable regression equation for each study site. The two sets of equations were combined to estimate benefits as a function of streamflow; that is, a change in streamflows will change the number of trips and per person benefits per trip, and the authors take account of both factors.

46. King, D.A., and J.B. Hof. 1985. Experiential commodity definition in recreation travel cost models. Forest Science 31(2):519-529.

This paper analyzes travel cost method data with estimation and analytic techniques that were suggested in reference 13. Demand equations were estimated using two different specifications. In the first specification, travel cost and angler characteristics were the independent variables. In the second model, a dummy variable was used to partition the data on the basis of recreation experience using survey instrument items developed by B.L. Driver ("Item Pool for Scales Designed to Quantify the Psychological Outcomes Desired and Expected from Recreation Participation," Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, Mimeo) to specify recreation experience. The net benefits estimated from each specification are virtually identical; so including experiential differentiation for participation groups does not seem to be critical for developing benefits estimates from travel cost demand equations. However, this research does indicate that consumer surplus does vary among experiential groups, and this may be important for management decisions involving existing sites.

47. Marino, M.A., and H.A. Loainciga. 1985. Dynamic model for multireservoir operation. Water Resources Research 21:619-630.

The timing of multireservoir releases is one of a number of water management policies that affect the net benefits levels of instream flows. This paper deals with computational procedures for maximizing certain objective functions via various release regimes. The algorithms suggested incorporate stochastic elements of the problem. The California Central Valley Project (NCVP) reservoirs discussed here are operated by the U.S. Bureau of Reclamation and the California Department of Water Resources, and they attempt to provide water for environmental control and enhancement, fish and wildlife requirements, river navigation, and recreation. Hence, maintenance of instream flows <u>should be</u> an integral part of the objective function; however, nonmarket benefits are not formally incorporated in this model.

48. Palmer, R.N., and R.M. Snyder. 1985. Effects of instream flow requirements on water supply reliability. Water Resources Research 21(4): 439-446.

This is an interesting paper on multipurpose water basin uses. However, it does not incorporate formal economic analysis into the multipurpose riverine resource allocation problem. The authors contend that the existing methods for assessing instream flow requirements for fish and wildlife habitat are still relatively crude and need further development and refinement. Among the instream flow requirement (IFR) methods that the authors review are the Tennant or Montana method, the Robinson or Connecticut method, and a USFWS Region 5 (New England) method. The authors argue that the limitations of these methods include the assumptions that past hydrologic and hydraulic parameters will not change significantly over time and that past flows can be used to estimate optimal flows. They also argue that these approaches do not consider the cumulative impacts of low flows on fish populations. But the assertion that the IFR methods suggested above imply an aquatic resource management philosophy based on past conditions rather than minimizing adverse impacts seems to involve a fundamental mistake in analysis. There are two difficulties in setting instream flow requirements. The first is specification of the objective function so as to account for nonmarket outputs (once uncertainty enters the picture, one must carefully justify passage from expected utility maximization to maximization of expected net benefits); the second is to accurately specify and quantify the constraint set. It is not implausible that noneconomists would be unaware of the intricacies, indeed, impossibility, of separating the two elements of the problem when uncertainty is a key element of the analysis. But surely the authors should have recognized that these IFR methods attempt to specify the constraint set in a quantitative fashion, so that quantitative assessments of net benefits can be used as decision making tools.

The authors discuss the Instream Flow Incremental Methodology (IFIM). One error in their discussion stems from the assertion that water quality assessments are not a part of IFIM studies; water quality assessments can be an integral part of IFIM studies (see Bovee "A Guide to Stream Habitat Analysis Using the Instream Flow Incremental Methodology," Chapter 5, Instream Flow

Information Paper 12. U.S. Fish Wildl. Serv. OBS-82/26. 248 pp.), and they are included in the macrohabitat assessment portion of such studies.

The authors convincingly quantify the physical trade-off between IFR levels and the likelihood of municipal water supply shortfalls for a case study that involves the Cedar River and the City of Seattle. Such a result is to be expected; it is surprising that the authors seem to be unaware of attempts of economists to evaluate the trade-offs between municipal withdrawals and instream flows. In view of the many efforts by economists to evaluate these benefits, the authors statement that " . . . benefits accruing from IFR are not quantifiable in economic terms under the current IFR methodology" seem both erroneous and irrelevant. Finally, the authors seem to be unaware that the National Ecology Research Center recommends that the high, low, and normal flow-year trade-off calculations performed by the authors should be a part of all IFIM studies.

49. Brookshire, D.S., L.S. Eubanks, and C.F. Sorg. 1986. Existence values and normative economics: implications for valuing water resources. Water Resources Research 22(11):1509-1518.

This paper examines the role of existence values in establishing instream flow values for purposes of whitewater rafting, water quality benefits, and fishing benefits.

50. Howe, C.W., D.R. Schurmeir, and W.D. Shaw, Jr. 1986. Innovative approaches to water allocation: the potential for water markets. Water Resources Research 22(4):439-445.

The authors advocate greater use of water markets, particularly in the arid West. The authors believe that water markets guarantee flexibility; short-run changes in supply due to sharp changes in climatic conditions and seasonal shifts in demand make flexibility a highly desirable attribute of any water allocation scheme. They also assert that water markets provide security of tenure (no owner has to sell), and that market transactions guarantee fairness between buyers and sellers. The conventional yardstick for economic efficiency is the ability of the allocation mechanism to equate the marginal costs of supply with the marginal value or marginal value product of the commodity; while water markets are not perfect in this regard, the authors assert that they are as good or better than most alternatives. They advocate greater institutional flexibility in the purchase and sale of instream flow rights. Only a rather narrow set of State agencies can acquire instream flow rights in certain States. The authors would like to see statute changes that allow both local governmental agencies and private entities to acquire instream flow rights.

The discussion of the shortcomings of water markets is instructive. However, the authors could have linked the shortcomings of water markets to various physical attributes of water, including bulkiness (high transport costs) and the difficulty of storing large quantities of water (due to seepage and evaporation).

51. Livingston, M.L., and T.A. Miller. 1986. The impact of Western instream water rights on choice domains. Land Economics 62(3):269-277.

This paper deals with the indirect economic effects of granting instream flow rights to a government agency or private economic entity. The relative seniority of the instream flow rights and the stream reach for which the rights are applicable can have subtle and important effects on the allocation of water to various diversionary or consumptive private uses. The authors assert that the seniority and the longitudinal placement of an instream flow right affect the "choice domain" of those who hold private water rights on the stream. By this phrase they refer to the fact that the effect is similar to a change in the initial resource endowments of these private agents, so the impact is difficult to analyze with the conventional Pareto efficiency criterion.

52. Loomis, J.B., C. Sorg, and D. Donnelly. 1986. Economic losses to recreational fisheries due to small-head hydro-power development: a case study of the Henry's Fork in Idaho. Journal of Environmental Management 22:85-94.

The authors estimate the loss in recreation (fishing) benefits due to small hydropower development projects. The site in question is on Henry's Fork of the Snake River in eastern Idaho. The authors believe that such calculations should be made routinely in assessing the economic effect of small hydropower projects. Also, these calculations should be an integral part of the FERC (Federal Energy Regulatory Commission) permit process. FERC is not required, by law, to consider quantitative assessments of economic efficiency losses, though other Federal agencies (including the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation) are required to make such assessments (under the U.S. Water Resources Council's Principles and Guidelines).

The authors quantify the benefits of development as the difference in the costs of energy supplied by the hydro project and the cost of energy from alternative sources. They combine the travel cost method (TCM) and contingent valuation method (CVM) to estimate the net (net of travel costs) benefits losses from a 50% reduction in fishing catch, a 75% reduction in fishing catch, and a 50% reduction in the average size of fish taken in this river. Those losses are, respectively, $920,000 per annum, $1,360,000 per annum, and $1,070,000 per annum.

53. Bishop, R.C., K.J. Boyle, M.P. Welsh, R.M. Baumgartner, and P.R. Rathbun. 1987. Glen Canyon Dam releases and downstream recreation: an analysis of user preferences and economic values. Glen Canyon Environmental Study Report #27/87. 188 pp. [Available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161, as NTIS Report #PB 88-183546/AS.]

Glen Canyon Dam opened in 1963. It is located on the Colorado River in northwestern Arizona. This study imputes recreational values to various

streamflow levels of the Colorado River between the dam and Lake Mead. The flow levels of this stream reach are heavily affected by the flow releases from the dam. These release rates may be as low as 1,000 cfs (cubic feet per second). When the dams eight turbines are operating at capacity levels, the release rate is 33,500 cfs. Additional release capacity is available; there are four 96-inch-diameter bypass tubes that can be used to bypass the turbines. These bypass tubes have a combined capacity of 17,000 cfs. When the reservoir, Lake Powell, is full, an additional 278,000 cfs can be released through the spillways.

This particular stream reach of the Colorado is heavily used by recreationists. In 1985, anglers made 6,029 trips to fish in this stream reach. When the dam was first opened, a number of trophy gamefish were taken from this site. However, because of heavy fishing pressure, there has been a decline in the number of large fish caught in recent years. There were 13,750 whitewater boating trips (11,382 commercial passengers and 2,368 private boaters) taken in 1985. A substantial part of the logic of the study stems from analysis of the seasonal variation in use rates for the two recreational activities and the preferred flow regimes for each recreational activity in order to determine the annual flow regime that maximizes the total annual benefits conferred by the resource for the given hydrologic constraints.

The authors report that the majority of 1985 whitewater boating trips occurred in May through September, while the primary angling seasons occurred in the fall (September through November) and winter (January through April).

There are four features that distinguish this paper from other CVM studies of instream flows. First, the authors conducted "attribute" surveys that allowed them to elicit information from respondents (recreationists and tour guides) as to the flow attributes that were most important for each type of recreational activity. Second, they estimate willingness-to-pay for annual flow regimes as well as short-run discharge rates. Third, there is a careful, lucid discussion of dichotomous response bidding games, and the requisite mathematical techniques needed to convert the data from such instruments into conventional consumer surplus estimates. Fourth, this report distinguishes between constant flows of a given magnitude and flows with a given mean value and significant dispersion in flow rates around this mean value.

Maximum benefits conferred occurred for anglers at constant flow levels of 10,000 cfs ($126 per trip net of all expenses). But a fishing trip is worth only $87 (above expenses) if 10,000 cfs is the mean flow but there is significant variability in flow levels. This is less than the estimated net benefit per trip of $94 for a constant flow of 25,000 cfs. The preferred annual flow regime for anglers was one with low-to-moderate constant average monthly flow releases; for this regime, the net annual angling benefits were $734,798. Total annual benefits for all recreational uses were maximized ($8,977,913) by a regime of high constant summer flows, but low average daily flows and extreme fluctuations in the nonsummer months (September-May). The annual flow regimes attempt to incorporate the hydrologic constraints imposed on release schedules by the production of hydropower.

Maximum trip values for boaters occurred with constant flows of 29,000 to 33,000 cfs; the net benefits conferred were $898 per passenger trip on a commercial boat and $688 per trip on a private boat. The Glen Canyon fishery was created by the cold water that is released from the dam. Rainbow trout are the dominant gamefish species. Most of the fishing takes place in boats upstream from Lee's Ferry (most of the boating trips originate at Lee's Ferry) from boats. But some shore fishing takes place in the vicinity of Lee's Ferry.

54. Brown, T.C., and B.L. Harding. 1987. A preliminary economic assessment of timber and water production in subalpine forests. Pages 126-137 in Management of subalpine forests: building on fifty years of research. USDA Forest Service General Technical Report RM-149.

The authors note the similarity between their paper and the 1984 paper of Bowes, Krutilla, and Sherman (reference 38). This paper also describes vegetation management in the subalpine zone of the northern Colorado Rockies; once again the management program involves small clearcuts and thinnings in a lodgepole pine stand. However, only streamflows in the upper and lower Colorado River basins are affected in the paper by Brown and Harding.

Costs and returns are calculated on a per acre basis in the earlier paper; in the Brown-Harding model, the per acre calculations are supplemented by calculations of the total aggregate net benefits from treating a 334,600-acre lodgepole pine stand. Moreover, Brown and Harding use a more restricted range of pecuniary values to calculate the market return from a marginal acre-foot of streamflow. They consider only the enhanced hydropower output from the augmented streamflow levels, while Bowes, Krutilla, and Sherman considered hydropower, municipal-industrial, and irrigated agricultural outputs in their marginal value calculations. But the Brown-Harding model imputes a marginal social value to a nonmarket output. The augmented streamflow will lower the concentration of dissolved salts in the rivers and streams of the Colorado River basin (the lower reaches of the Colorado River are highly saline), thereby increasing the marginal value product of irrigation water. The omission of the calculation of the market value of the extra irrigation water is particularly striking because of the inclusion of the data and calculations on the value of lowering the salinity of irrigation water.

Because it omits industrial-municipal uses entirely, it is hardly surprising that the marginal per acre yields produced by the vegetation treatments in the Brown-Harding model are lower than for the Bowes-Krutilla-Sherman model. The various thinnings and cuts yielded an annual average of 124 board-feet per acre in the Brown-Harding model; the annual average total water yield was 55,583 acre-feet. Unfortunately, Brown and Harding also make little effort to quantify the nonpecuniary benefits of the vegetation treatments. The enhanced sediment of the runoff caused by the logging roads might sharply lower the net benefits of the augmented water yield to industrial-municipal users. The diminished water quality in various stream reaches would adversely impact aquatic habitat and contingent recreational benefits.

55. Loomis, J.B. 1987. The economic value of instream flow: a review of methodology and benefit estimates. Journal of Environmental Management 24(2): 169-179.

Loomis discusses the theoretical underpinnings of econometric methods for putting dollar values on instream flows of various magnitudes. The theoretical discussion is a brief review of Hicksian consumer surplus and its relevance when demand curves are shifted by varying amounts of some nonmarket good. The travel cost and contingent value methods of estimating the demand for river site recreation and derived demand for instream flows are reviewed. The hedonic property method is mentioned but not discussed.

56. Loomis, J.B. 1987. An economic evaluation of public trust resources of Mono Lake. Institute of Ecology Report No. 30. University of California, Davis. 137 pp.

This thorough, careful research product deals with willingness-to-pay for three alternative lake levels, by on-site visitors and California households, of Mono Lake. In 1940, the City of Los Angeles acquired water rights on the streams that feed Mono Lake. These rights, which sum to 100,000 acre-feet per annum, when exercised fully, lower the level of Mono Lake significantly, thereby diminishing the ecological value of this unique wildlife refuge and migratory bird sanctuary. Lowering of the water level in Mono Lake also significantly diminishes the aesthetic value of the lake and results in a higher number of days on which visibility is lowered by blowing dust from the dry portions of the lake bed. Mono Lake, which is located east of the Sierra Nevada mountains in the great basin, is hypersaline. The lake water is 1.5 times as saline as ocean water. This hypersaline condition prevents it from being a sport fishery, but makes it one of the most important bird sanctuaries in California. It is very productive of brine shrimp and brine flies, which are important habitat food sources for the 100 species of birds that inhabitat Mono Lake. Moreover, Mono Lake has islands and islets that are excellent nesting habitat, and cannot be reached by terrestrial predators. The food sources and the value of the island habitats are seriously lowered by the low lake levels caused by the 100,000 acre-feet per annum diversions.

The author estimates an aggregate willingness-to-pay to preserve the unique ecological and scenic benefits of Mono Lake by California households at $42.00 per household; the cost of obtaining hydropower and water (the streams that feed the lake also provide hydropower to the City of Los Angeles) from alternative sources is $2.64 per California household. Off-site benefits constitute over 90% (the 145,000 visitors per annum provide the remainder of the aggregate willingness-to-pay) of the aggregate willingness-to-pay. This lengthy, but interesting, paper includes a discussion of the impact of the questionnaire format on the mail survey results; this is called hypothetical-bias in the literature.

57. Ward, F.A. 1987. Economics of water allocation to instream uses in a fully appropriated river basin: evidence from a New Mexico wild river. Water Resources Research 23(3):381-392.

This paper is essentially the same as Ward's earlier paper (reference 44). The same travel cost method demand equations are estimated for a site on New Mexico's Rio Chama River. The questionnaire included questions on the number of trips and instream flow levels. After a flow-benefits function is specified, a discrete nonlinear programming model is developed and analyzed that specifies an optimal flow release regime from the City of Albuquerque reservoirs located upstream of the site. The optimal flow regime involves shifting flow releases from winter (when evaporation losses are low) to summer (when recreation benefits are high). The discrete nonlinear optimization model is not the stochastic optimization model used in the earlier paper.

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16. Abstract (Limit: 200 words)

Various quantitative techniques have been developmend recently for the economic assessment and valuation of instream flows. These techniques are discussed in detail in both the preface and the bibliography of this paper. The discussion focuses on instream flows as a renewable natural resource that provides unique habitat values for a wide variety of terrestrial and aquatic wildlife. The aquatic wildlife values inherent in the preservation of instream flows are closely connected with the recreational uses of the resource. Hence many of the technical discussions in the literature and much of the discussion given here deal with the application of recreation economics to the valuation of publicly owned riverine recreation sites.

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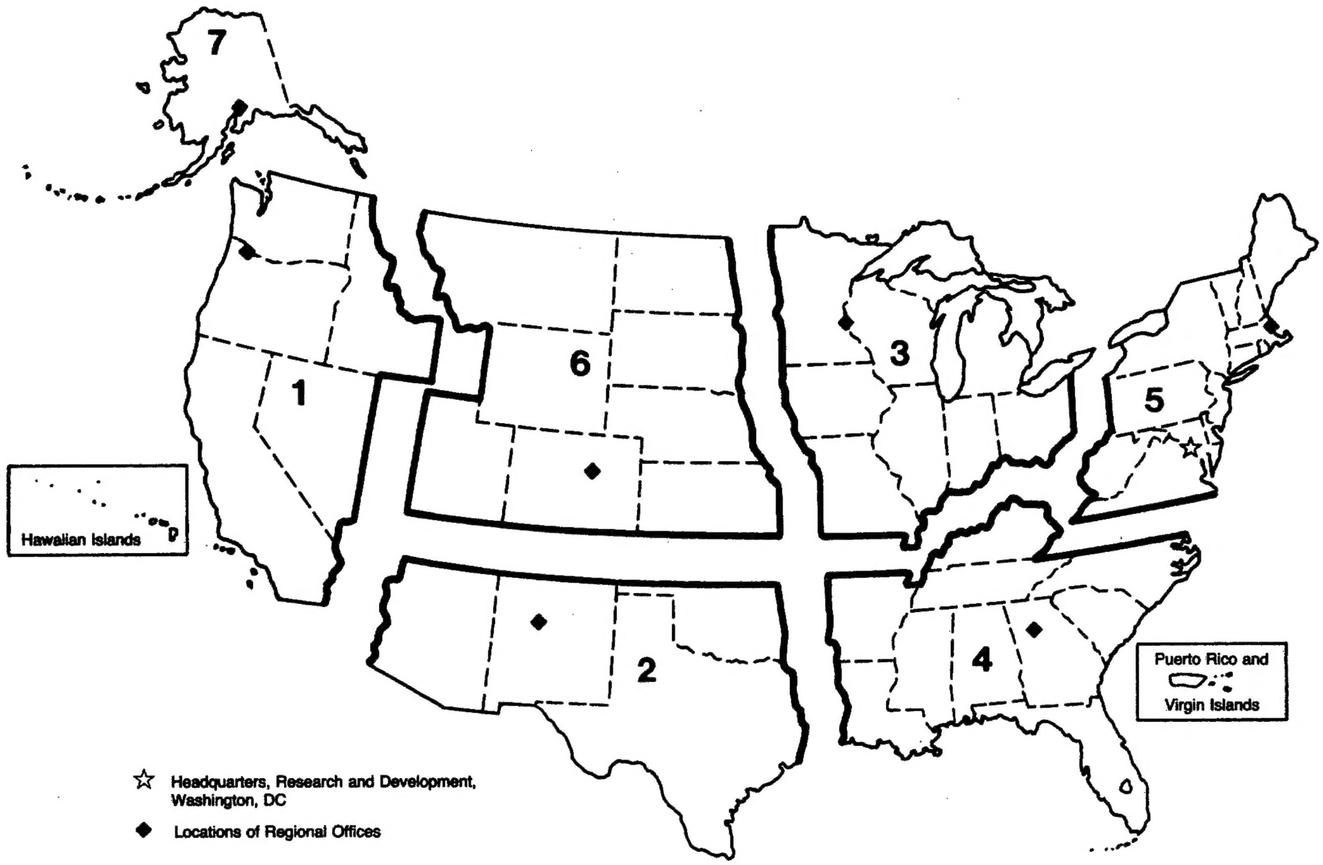

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